National Aeronautics and Space Administration

2008 ANNUAL REPORT TO THE ADMINISTRATOR

NASA INVENTIONS AND CONTRIBUTIONS BOARD

Inventing Exploration

ON THE COVER:
Depictions of various explorations vehicles to the Moon, Mercury, Mars, Jupiter, and Venus.

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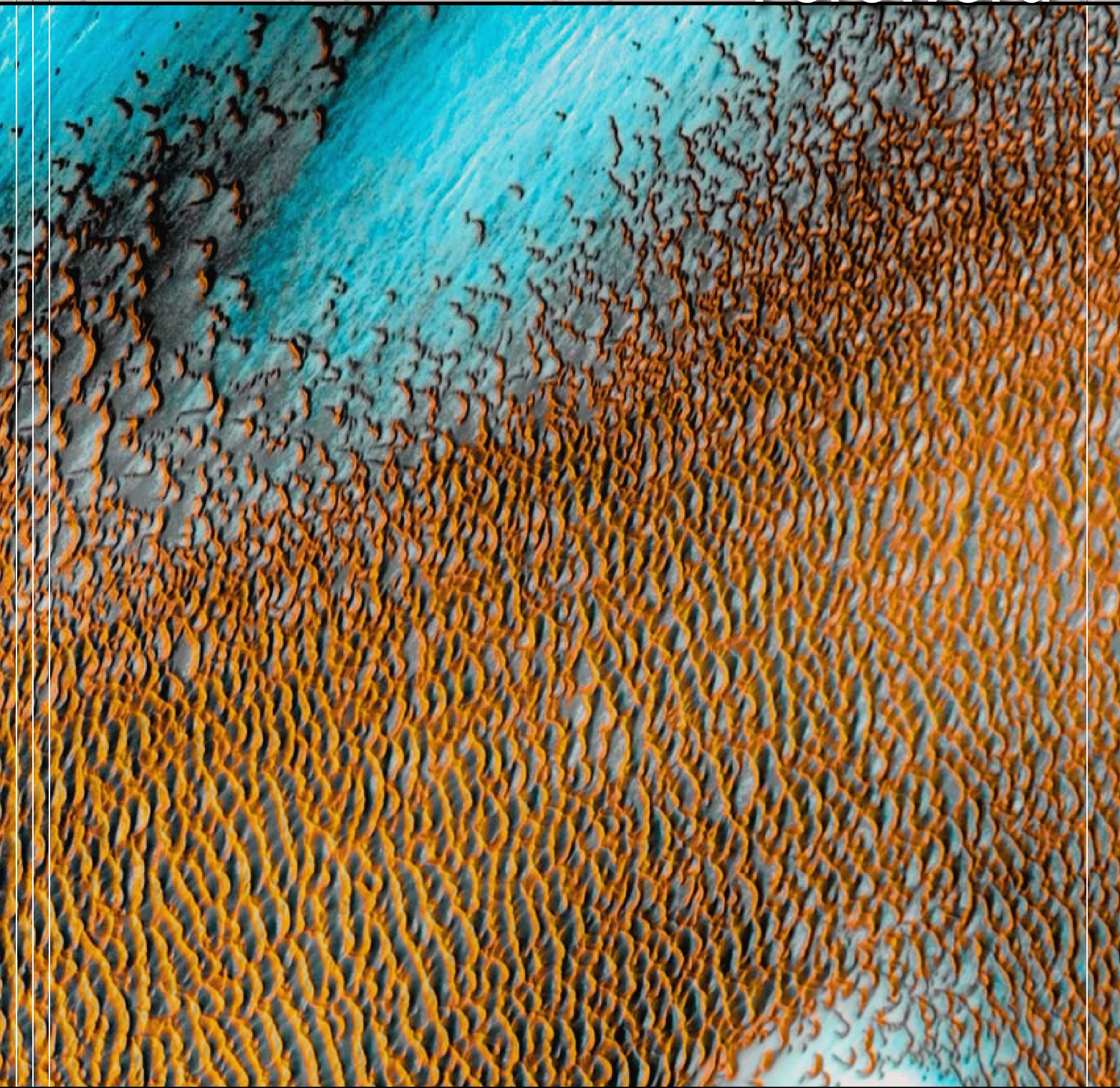
Foreword



Message from the Chair

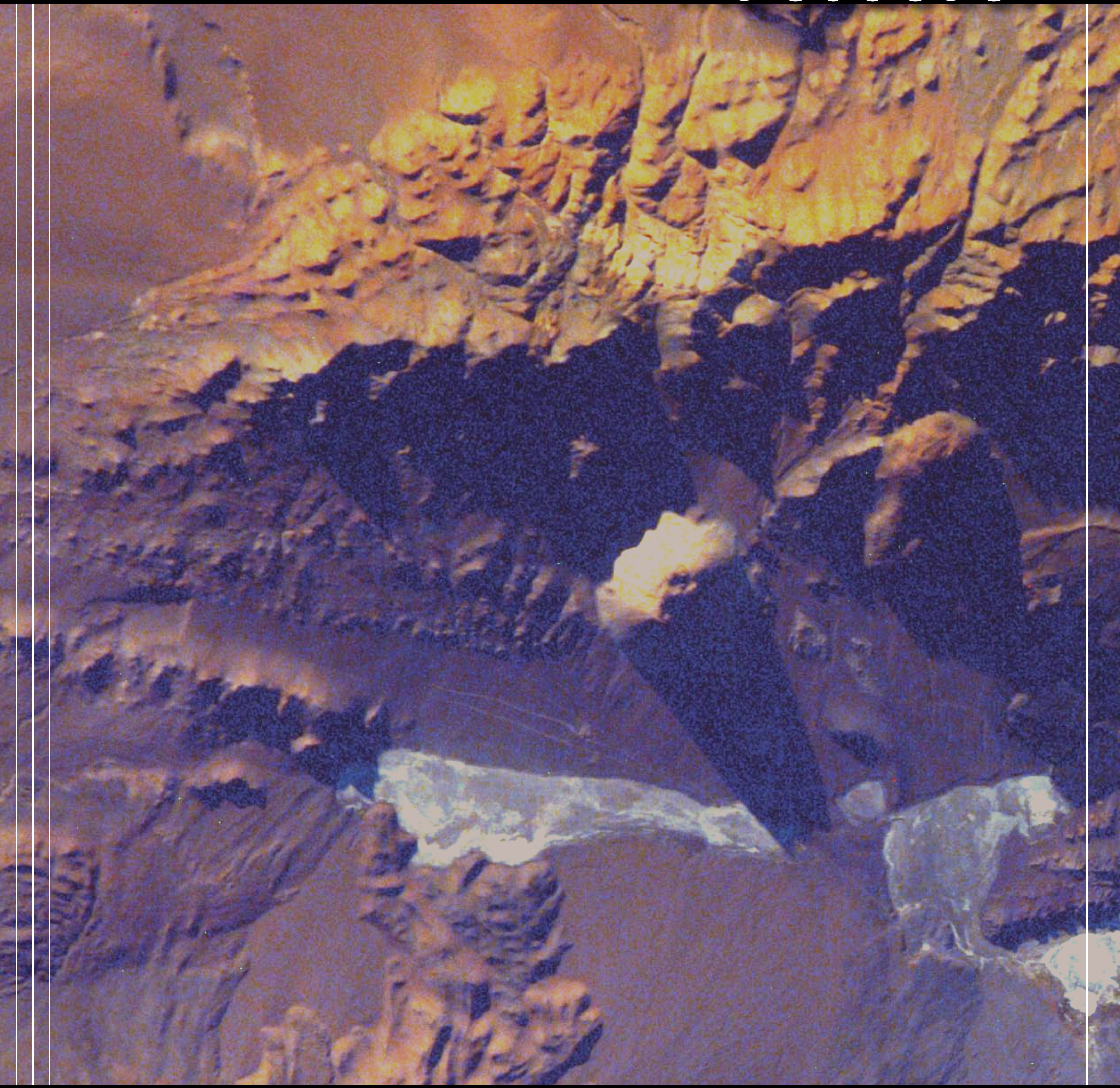
One of the more satisfying functions of the NASA Chief Engineer is to coordinate the recognition of outstanding NASA scientific and engineering aerospace accomplishments. Fifty years ago, the authors of the Space Act had the foresight to set this program in motion, and it continues to enhance the winning combination of the skilled NASA workforce and their challenging missions. Since then, the NASA Space Act Awards program has had an aggressive inventor-recognition philosophy. The 21-member Inventions and Contributions Board (ICB) and four staff members cull the huge array of NASA inventions and bring the best to light. Without this activity, many of the diverse accomplishments would undoubtedly go unnoticed in the undercurrents of our research activities. The world-class NASA engineers and scientists often do not request or require recognition and are content to serve the Agency with the satisfaction of discovery and the knowledge that they have done their jobs well. To stop there, however, would be to deprive their peers and the Nation of the wonder of these new acheivements. The Nation needs to know what is done behind the scenes to make technology work and to accomplish what it does, so this report is NASA's yearly chance to showcase some of these accomplishments.

With over 3,000 inventors sharing in over $2 million in awards, it has been a banner year for NASA inventions. As you will see in these pages, many of these inventions have very specific scientific uses, and some have the potential to change everyday life in a number of ways. Some are the results of entire careers of steady work, while others come from flashes of inspiration or the impetus of a new enabling technological development. NASA needs all kinds of inventions to accomplish new missions and raise the bar on scientific discovery, so managers are encouraged to use the Space Act Awards program as a vehicle to spur on discovery in every level of their organizations.

Dr. Michael G. Ryschkewitsch, Chair
NASA CHIEF ENGINEER

ENABLING
EXPLORATION

Introduction

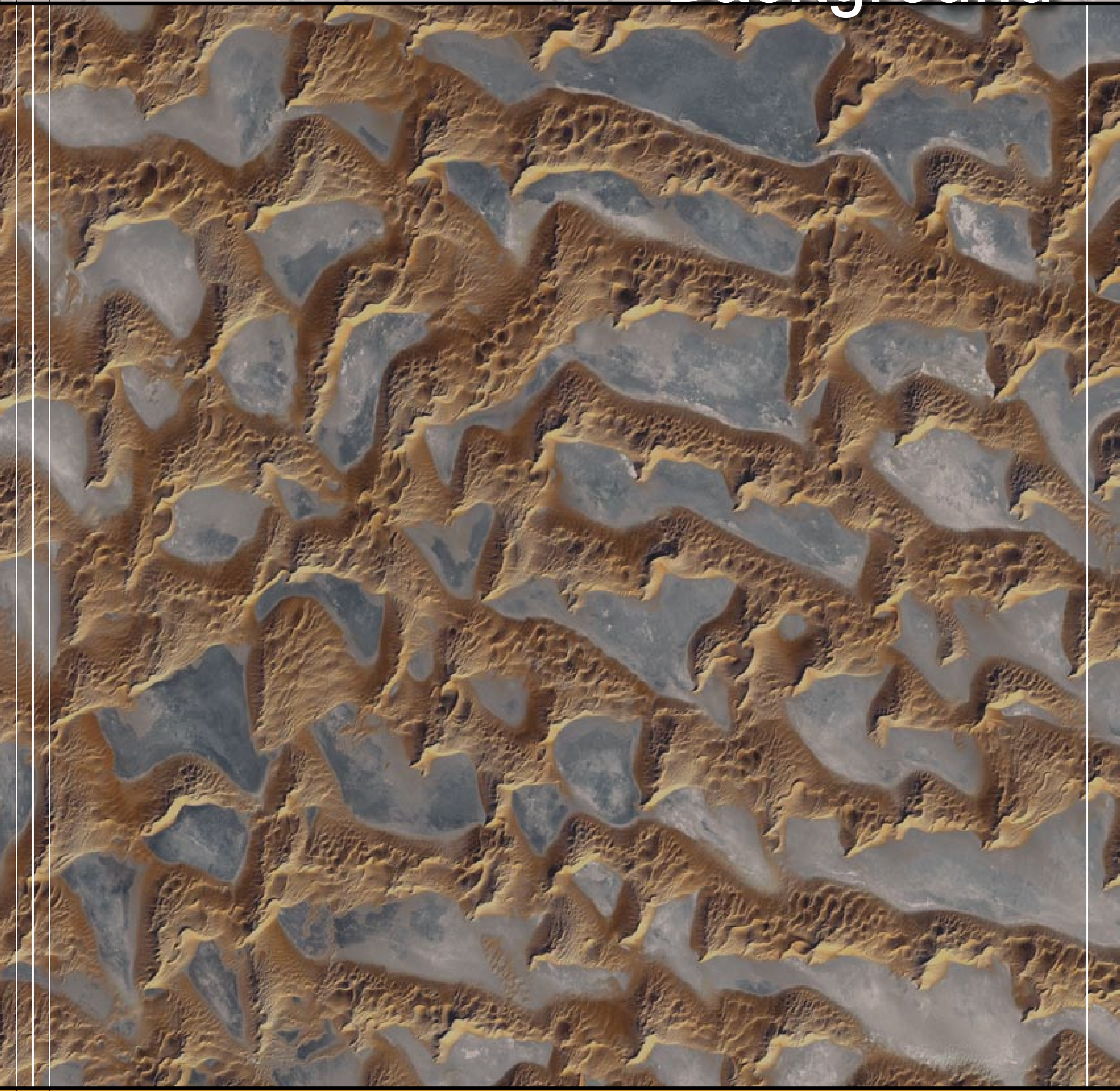


Enabling Exploration

The ICB makes recommendations to the Administrator for invention awards up to $100,000 and could award more with congressional notification. This year, the ICB approved over 3,000 individual cash awards totaling more than $2 million to those who contributed to the technical development of significant NASA-sponsored technologies. The 21-member ICB is comprised of technical specialists individually nominated by their home Center and appointed by the Administrator to provide the diverse expertise needed to evaluate new and unique technologies from the various Centers. With the assistance of four staff members and a legal counsel, the ICB reviews and judges contributions submitted for their value to the Government and the Nation. Many of these inventions and contributions have the potential to enable future space exploration and improve life on Earth.

RELENTLESS INNOVATION

Background



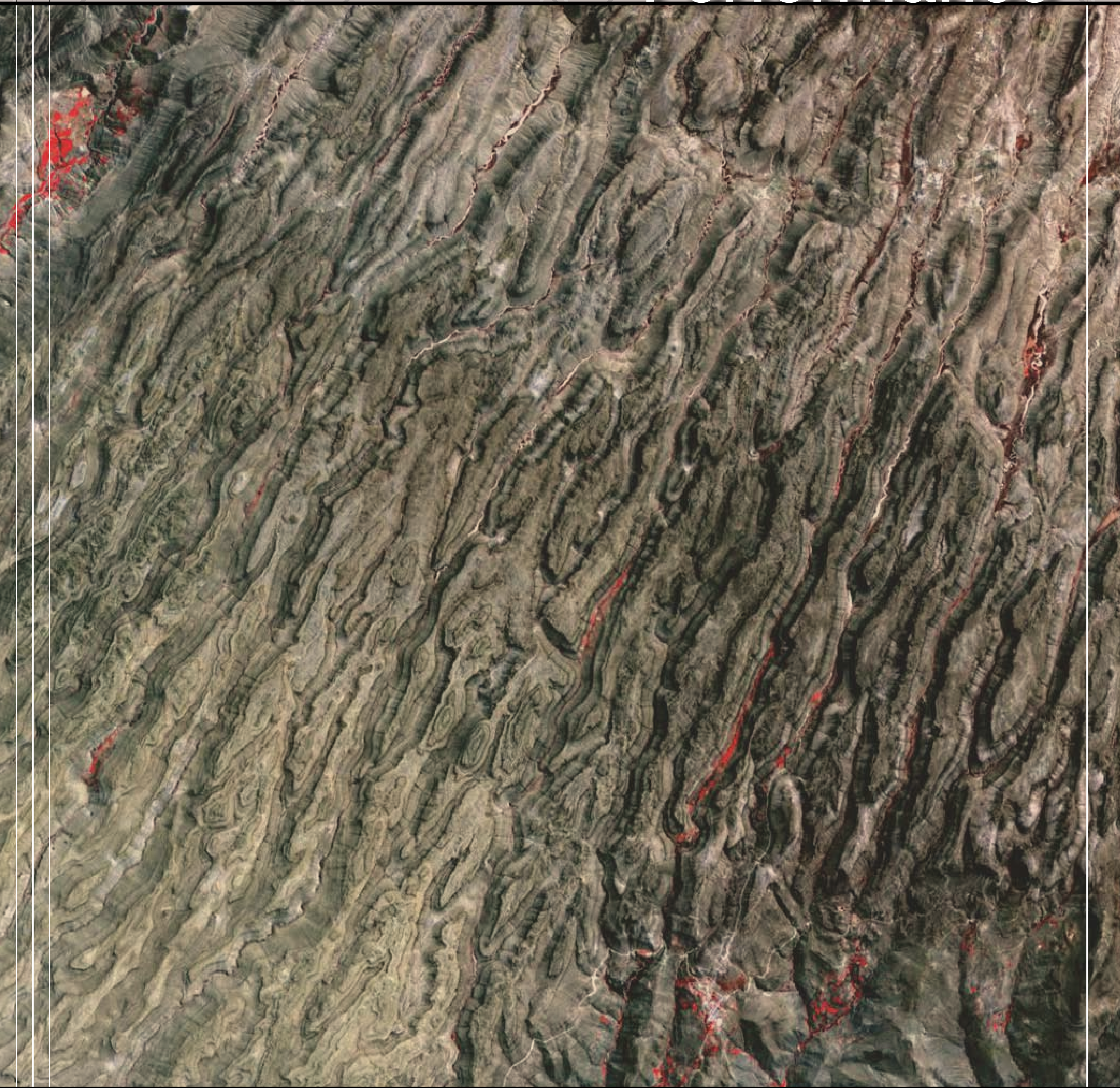
Relentless Innovation

The ICB has been steadfastly rewarding the efforts of NASA employees to push the exploration of flight and the universe forward for half of a century. To date, the ICB has presented more than 100,000 awards to inventors for the relentless and tireless innovations they have made to accelerate the progress of science and aerospace. The highlights of the last seven years of awarded technologies are available in the previous ICB annual reports, archived online at *http://www.nasa.gov/offices/oce/icb/Annual_Report.html*. To identify the best technologies, the ICB also conducts annual competitions to select and recognize NASA's Invention of the Year and Software of the Year (see: *http://www.nasa.gov/offices/oce/icb/Yearly-Comps.html*).

While it is difficult to estimate the impact of these inventions on the U.S. economy and world commerce, it will be in the billions of dollars. The descriptions of past and current NASA-sponsored inventions show that they accomplish their intended purposes well, but we have yet to see all the ways that these technologies may directly benefit us.

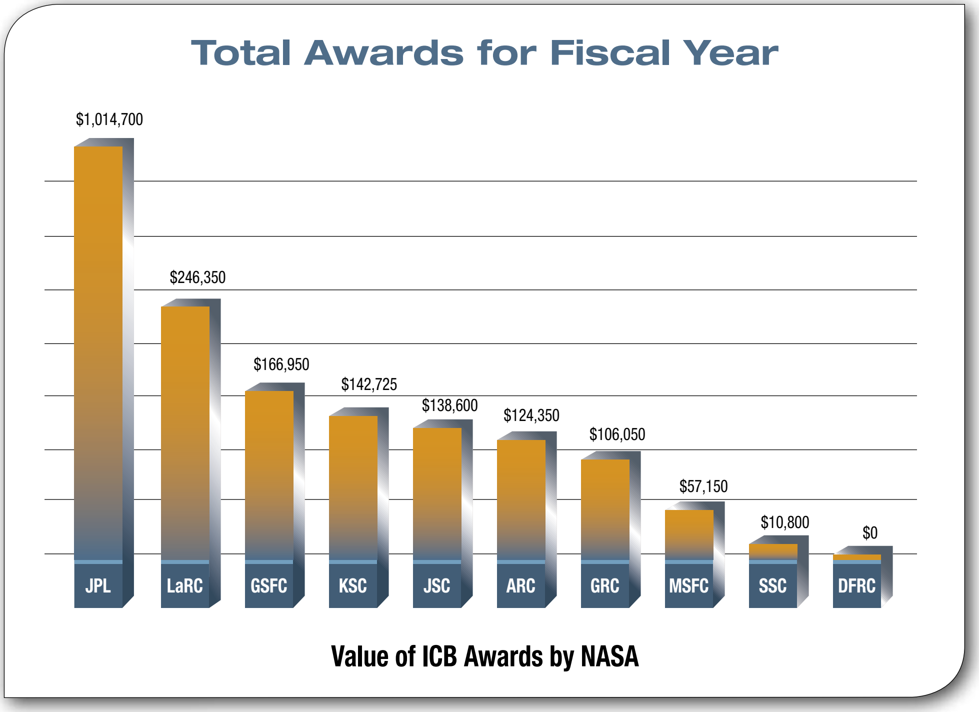
2008 AWARDS
STATISTICS AND METRICS

Performance



FY 2008 was one of the few years in which the ICB awarded more than $2 million. While there are many ways to display the statistics, combining all Centers' statistics together shows the following:

1. 1,575 NASA Tech Briefs authors were recognized.
2. 529 patent holders were recognized.
3. 697 software authors were recognized.
4. 550 individuals received ICB action awards for other types of contributions to NASA's aerospace endeavors.
5. There were 16 Exceptional Cases—inventions with at least one inventor who received an award of $5,000 or more.



The ICB awarded more than $2 million to multiple NASA Centers during FY 2008.

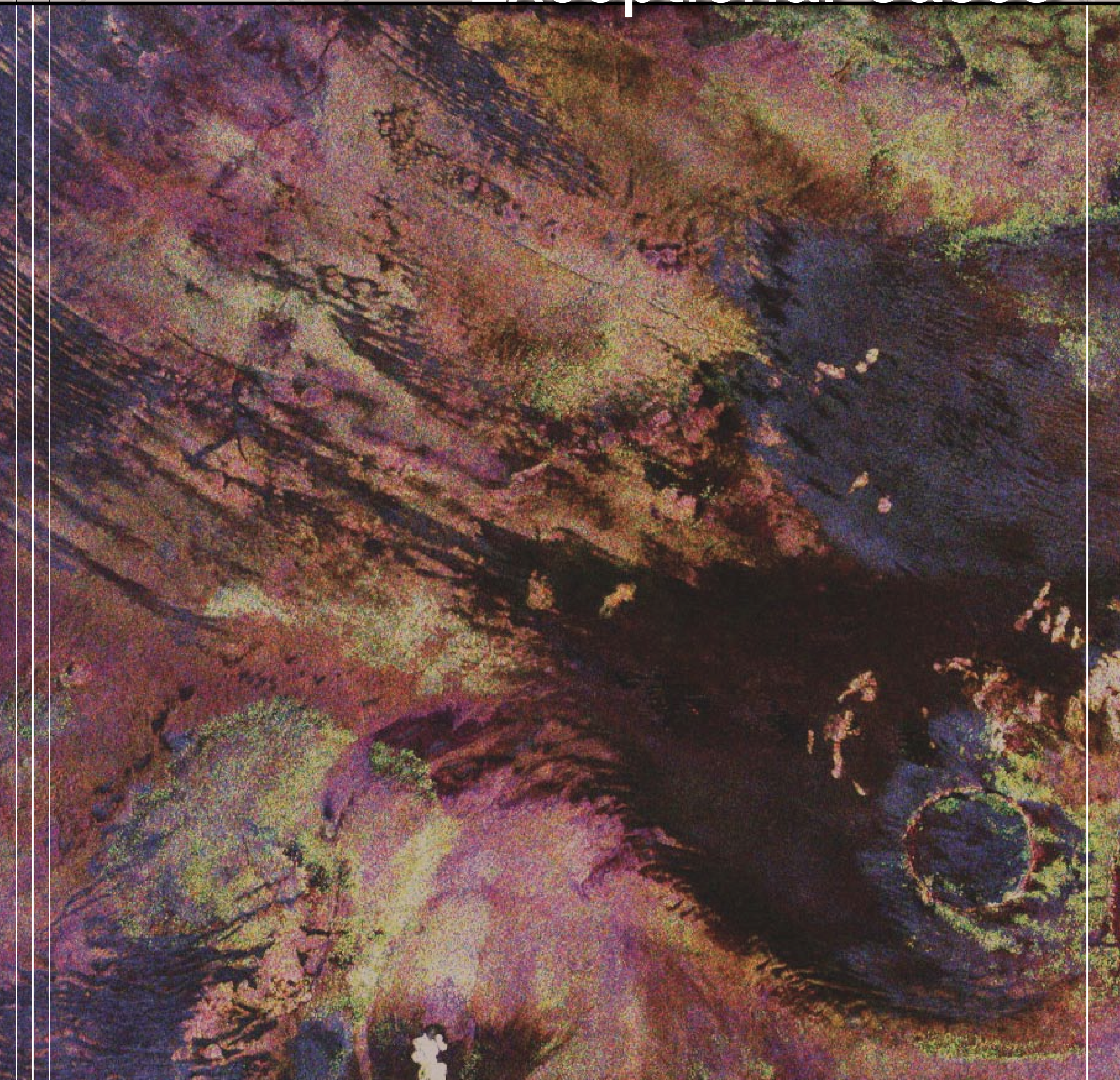
Descriptions of the Exceptional Cases follow. A unique tracking code identifies each technology; the codes have three letters, and they designate the lead NASA Center for code development. A five-digit number was assigned to each code at the time it was reported to NASA.

Center Codes:

- Ames Research Center: ARC
- Dryden Flight Research Center: DFRC or DRC
- Glenn Research Center: GRC or LEW (formerly Lewis Research Center)
- Goddard Space Flight Center: GSC or GSFC
- Headquarters: HQ
- Jet Propulsion Laboratory: JPL or NPO (formerly NASA Pasadena Office)
- Johnson Space Center: JSC or MSC (formerly Manned Spaceflight Center)
- Kennedy Space Center: KSC
- Langley Research Center: LaRC or LAR
- Marshall Space Center: MSFC or MFS
- Stennis Space Center: SSC

SOFTWARE AND INVENTION OF THE YEAR

Exceptional Cases



Yearly Competitions

The 2007 Government Invention of the Year is ARC-12011-1&2: PICA and SIRCA Low-Density Resin Impregnated Ceramics

It is a well-known fact that one of the toughest ongoing problems NASA deals with is the heat of entering a planet's atmosphere at suborbital speed. This patented suite of ceramic ablator technologies has been used on four missions, all with good success. The innovation lies in the ability to tailor the density of thermal protection systems by forming woven fiber matrices. Resin is then deposited to the desired thickness on the fibers by controlling the evaporation of excess resin or carrier solvent from the article. This results in the appropriate resin coating thickness for each application. A later patent focuses on layered combinations of materials made using the above method. The technology has been licensed, and the nearly infinite combinations of fibers and resins that could be developed using this method should enable broad commercial, government, and military applications.

Artist concept of thermal protection systems and low-density resin impregnated ceramics on a reentry capsule.

The 2007 Commercial Invention of the Year is LAR-16615-1&2:
FPF-44 Polyimide Foams

This invention meets a growing need for high-performance flexible polymeric foams for cryogenic, thermal and acoustic insulation, fireproofing, energy absorption, and other applications. Langley Research Center's (LaRC's) Flexible Polyimide Foam is made from four ingredients and was invented by four people, hence the name FPF-44. This polyimide foam technology exceeds the performance of commercial foams used on the Space Shuttle External Tank; it is more durable, lighter, and it has a higher use temperature. Virtually anywhere foam is used, FPF-44 applies to a wide range of industrial uses, including flame retardants, fire protection, thermal insulation, acoustic insulation, gaskets, seals, and vibration damping pads. The exceptional flame retardant nature of FPF-44 products can improve the safety of watercraft, aircraft, spacecraft, electronics and electrical products, automobiles, recreation equipment, and buildings. Increased use of FPF-44 includes hundreds of thousands of board feet purchased by the U.S. Navy and U.S. Coast Guard for flame retardant ship insulation. The licensee and co-inventor, Polyumac, Inc., has increased production to meet increased demand.

Shown are three properties of FPF-44 polyimide foams, the 2007 Commercial Invention of the Year. From left to right: fire protection, flexibility, and ease of production.

2008 Software of the Year

The 2008 Software of the Year is Glenn Research Center's (GRC's) LEW-18319-1:
Optimal Trajectories by Implicit Simulation, Version 4 (OTIS4)

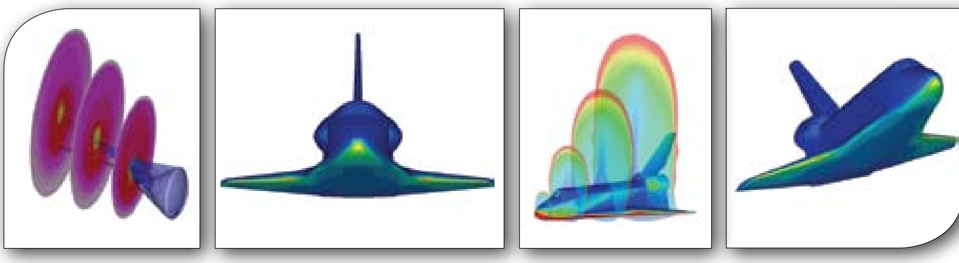
The OTIS4 program is used to perform trajectory performance studies based on many variables to determine the best trajectory for a given mission. A user can simulate a wide variety of vehicles such as aircraft, missiles, reentry vehicles, hypervelocity vehicles, satellites, and interplanetary vehicles. The OTIS4 vehicle models are defined by user inputs; there are no embedded, vehicle-specific aerodynamic or propulsion models. OTIS4 is primarily a point mass, three-degree of freedom (3DOF) simulation program for single vehicles. Options allow six-degree of freedom (6DOF) simulations and several types of special multiple vehicle problems. The program name is derived from one of the program's methods used to solve differential equations, which was distinctive at the time of OTIS4's origin. Trajectory integration can be specified as implicit, explicit, or analytic. The program can generate flight paths to any of the major bodies in the solar system. Using this program, trajectory generation, targeting, and optimization can all be accomplished. OTIS4 provides two general modes of operation: explicit trajectory integration (or propagation) and optimization using either explicit or implicit integration methods. OTIS4 provides a number of implicit integration schemes, including Gauss-Labatto methods and pseudospectral methods; it can optimize with explicit integration and parameterized suboptimal controls. Implicit integration provides the OTIS4 user with rapid, robust, and accurate solutions to trajectory optimization problems.

NASA engineers discuss results from the Flight Optimization Program, which can simulate flight paths to any major body in the solar system on a wide variety of vehicles.

2007 Software of the Year

The First Co-Winner of the 2007 Software of the Year is ARC-15022-1:
The Data-Parallel Line Relaxation (DPLR) Code

Pronounced DEE-plur, DPLR analyzes and predicts the extreme environments human and robotic spacecraft experience during extreme high-speed entries into planetary atmospheres. These high-fidelity simulated entry environments are necessary for engineers to design and apply thermal protection materials to withstand extreme environments, since they cannot be duplicated in full scale at any Earth test facility.



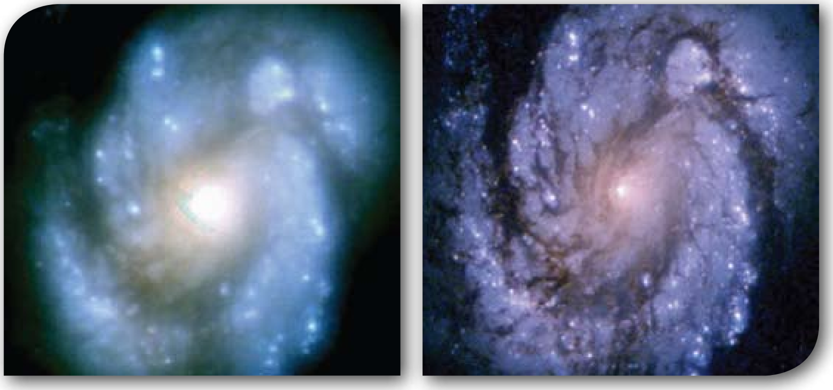
These four images show DPLR simulations on the Space Shuttle. The DPLR software has already made a positive impact throughout the aerospace industry.

DPLR has impacted science and technology beyond its direct support of NASA primary mission objectives. It has been transferred to multiple government, industry, and university partners for use within the Department of Defense (DOD), the Department of Energy (DOE), civilian aerospace, and fundamental research endeavors. Several DPLR-derived tools are in active development in universities and industry across the country. DPLR already has a major impact on NASA and defense aerospace industries, and it can potentially benefit civilian aerospace as well.

Other uses of DPLR include breakup of deorbiting debris—as demonstrated recently in a collaborative effort between NASA Ames Research Center (ARC) and Kennedy Space Center (KSC)—and missile plume signature analysis. Potential applications include all civilian and military entry vehicles, hypersonic and supersonic cruise vehicles, and commercial and military launch systems. The performance and physical modeling innovations in the DPLR software have the potential to greatly enhance the design and optimization of such systems. Also, the generalized chemical kinetics and transport property packages in DPLR make the software valuable for the simulation of combustion flows for both aerospace and non-aerospace applications (such as reactors or combustion engines).

The Second Co-Winner of the 2007 Software of the Year is the Jet Propulsion Laboratory's (JPL) NPO-43857-1: Adaptive Modified Gerchberg-Saxton (MGS) Phase Retrieval Program

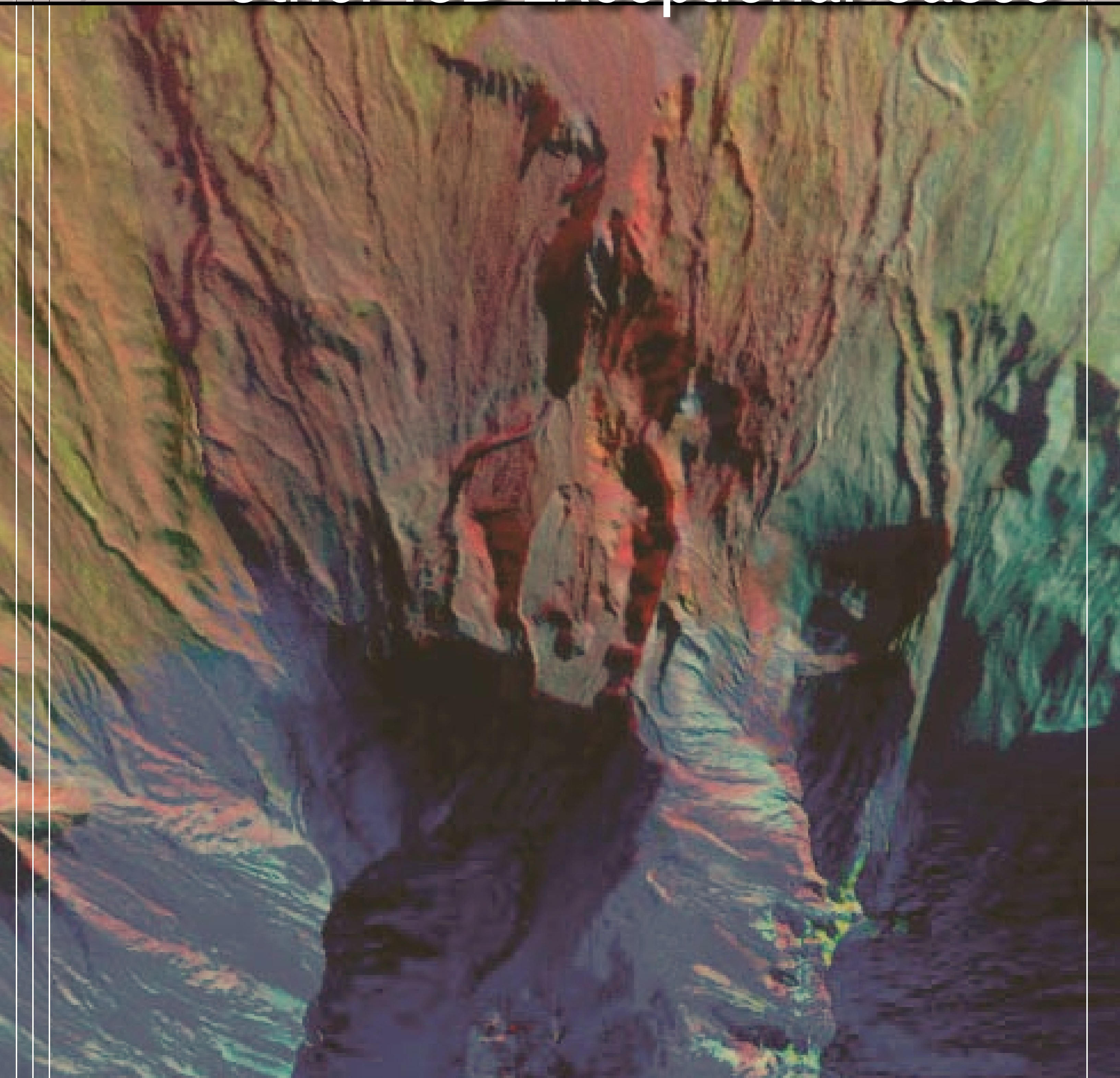
The MGS uses a telescope science camera with innovative and robust algorithms to characterize possible errors in imaging performance. The software has been integrated into calibration control loops to correct those errors, and it can achieve orders of magnitude improvement in sensitivity and resolution. It is in use at the California Institute of Technology's Palomar Observatory and played a significant role in designing NASA's James Webb Space Telescope, scheduled to launch in 2013. Early work for the JPL software was based on NASA's Hubble Space Telescope correction techniques. The MGS can be applied to other sciences and systems that use light, such as laser communications and extrasolar planet detection.



The MGS software demonstrated on before and after photos of a spiral galaxy. The right-hand image was improved by MGS.

STANDING OUT IN A DISTINGUISHED CROWD

Other ICB Exceptional Cases

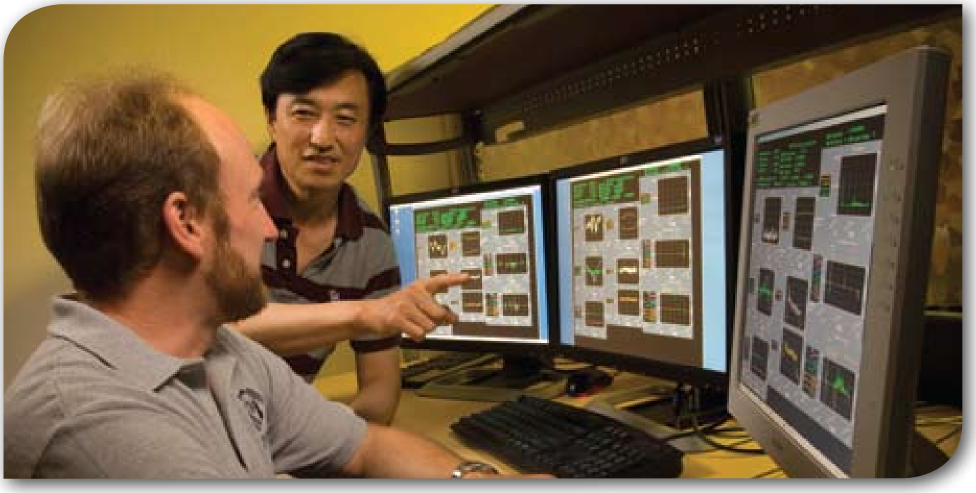


2008 Software of the Year Runner Up

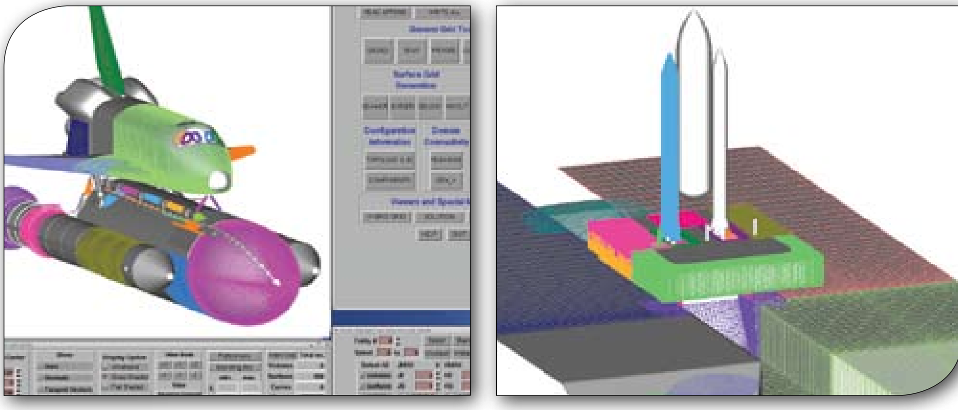
ARC-15058-1: Inductive Monitoring System (IMS)

This software is an innovative Integrated System Health Management (ISHM) application that uses data-mining techniques to produce real-time health monitoring capability for complex systems. The IMS automatically learns typical system behavior by discovering parameter relationships in archived nominal data and constructing general classes representing normal system operation. Operational data are then compared to these classes to detect subtle yet systemwide off-nominal system behavior and to alert operators or other automated systems to possible subsystem failures or impending failures earlier than conventional methods would. The IMS uses a flexible technique applicable to most domains with adequate data collection capability, including mechanical, electrical, thermal, environmental, biological, and hybrid systems. Successful NASA applications of the IMS have ranged from real-time monitoring of aircraft engine and control systems to anomaly detection in Space Shuttle wing temperature sensors from STS-107 launch data. It has demonstrated its ability to identify system problems by observing small changes in many related parameters long before any single change would raise a flag to system monitors.

The IMS is coded in the C++ programming language with a simple, adaptable data interface for portability. It has been deployed on numerous computing platforms and integrated with diverse data systems, including flight-qualified hardware on an aircraft 1553 data bus and the Johnson Space Center (JSC) mission control Information Sharing Protocol (ISP).



NASA engineers use the IMS software to identify errors and anomalies in aircraft and Space Shuttle control systems.



Shown are two analyses of the Space Shuttle created in part with the Chimera Grid Tool software. Multiple software releases and a large user base prove the software's success.

2007 Software of the Year Nomination

ARC-16025-1: Chimera Grid Tools—Software Tools for Modeling and Simulation of Aerospace Vehicles

The safety and the success of many NASA aeronautics and space missions depend on accurate modeling and simulations of a wide variety of aerospace vehicles. Such simulations typically begin with the creation of a computational grid representing the geometry of the vehicle and its vicinity. This grid is used to compute the aerodynamic flow over the vehicle to extract the aerodynamic and dynamic performance of the vehicle. The grid must be fine enough in areas of interest to provide engineers enough data, but not so fine in other areas that the computation time is too long. Grid generation is an important, highly challenging, and often pacing step in the high-fidelity simulation process, which can take weeks or months using conventional tools.

After solutions are computed, analyzing the vast amount of data and extracting useful information also can take significant human time and effort. This is where the Chimera Grid Tools (CGT) software package simplifies pre- and post-processing of computational simulations of complex configurations to facilitate setup and result analysis. The package contains about 60 modules for the manipulation, processing, generation, and visualization of geometry and grids. It also has modules to simplify the preparation of inputs to the flow solver and tools to assist in the analysis and visualization of flow solutions. It is a great help in the pre- and post-processing of prescribed and 6DOF multibody dynamics simulations as well.

This useful tool is well documented by 84 software releases, a 550-person user base, and 31 related technical publications. It has been used on OVERFLOW processes for the Shuttle Return to Flight (RTF), Shuttle subsystems, KSC support buildings, Alaskan islands current modeling, Crew Exploration Vehicle (CEV) design, supercomputer rooms, the ARES launch vehicle design, and much more. It has even helped simulate various sporting activities—from car and yacht racing to the aerodynamics of golf balls.

NASA engineers use the IRC architecture to control fleets of remote devices capable of collecting surface and environmental data.

2007 Software of the Year Nomination

GSC-14308-1: Interoperable Remote Component (IRC) Architecture

The IRC architecture is a flexible, platform-independent application framework that is well suited for the distributed control and monitoring of multiple remote devices and sensors. The architecture's strength is in its capability to be configured for a specific application based on eXtensible Markup Language (XML) descriptions; the architecture can be customized for user-specific applications and interfaces. For all NASA projects in which IRC has been deployed, IRC is the sole provider of instrument, system, or device control and data collection. The value of the data is often irreplaceable in rare events, and the inventors have maintained IRC framework data integrity from initial receipt and processing to archiving. IRC also is trusted to remotely control highly valued resources, such as one-of-a-kind instruments.

2007 Invention of the Year Nomination

GSC-14435-1: Innovative Manufacturing Procedure for Low Cost and High Quality Carbon Nanotubes and **GSC-14601-1:** Methods for Manufacturing High Quality Carbon Nanotubes

These patented and commercially licensed inventions focus on the relatively inexpensive production of high-quality single walled carbon nanotubes (SWCNTs) using a commercial arc welder in an inert environment without the need for metallic substrates. This eliminates the need for complex and hazardous acid bath systems to remove the substrate metals from the SWCNTs. One separates the SWCNTs from the other welding products by suspending the SWCNTs in a solvent and then removing the mixture and evaporating the solvent. The resulting production cost can be reduced by a factor of 10 and enable more researchers to access this new type of material.

GSC-15338-1: Method for Non-Destructive Evaluation of Thermal Protection System Materials and Other Materials via Ultraviolet Spectroscopy

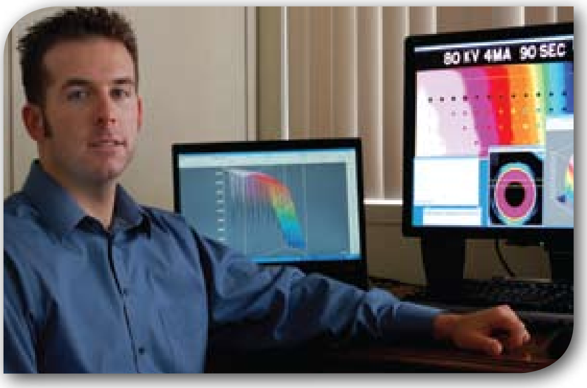
This technology is a new nondestructive method for evaluating degree of cure, variations in chemical composition, and defect states in resin-based composites and metal oxides—data currently unobtainable through x-ray testing or other methods capable of in-field measurements. Featuring a novel use of ultraviolet (UV) spectroscopy and imaging, this highly portable technique has proven effective at testing materials used in spacecraft thermal protection systems. Tests have shown that this technique provides comparable chemical composition information as destructive methods; it can be used on both conductive and nonconductive materials, penetrating to a depth of 200 μm. The invention has been used to test candidate materials for the Thermal Protection System (TPS) on NASA's Stardust sample return capsule to verify that the contents had not been overheated during reentry. Other projects include the Cometary Sample Return Capsule and the Orion Crew Exploration Vehicle design.

This technology also was used in collaboration with the Non-Destructive Evaluation Branch at LaRC in NASA's RTF effort. The tool was used to noninvasively detect cracks and inhomogeneities in the surface coatings of the foam-impacted, reinforced carbon-carbon components on the leading edge of the Shuttle wing. From a commercial standpoint, there is interest in using this technique to evaluate manufacturing processes of TPS materials for other, non-NASA reentry vehicles and for chemical identification of space- and Earth-based objects.

A demonstration of how UV spectroscopy tests spacecraft TPS materials.

KSC-13206-1: Optical Density Analysis of X Rays Utilizing Calibration Tooling to Estimate the Thickness of Materials

Contact tooling restricts most Non-Destructive Evaluation (NDT) methods in their coverage area, but x rays allow for a non contact remote method to see through complex configurations (i.e., in joints or adjacent to welds). This is useful when complete coverage of a part by the conventional NDT equipment may not be possible due to its complex shape. Using standard off-the-shelf analysis software and a digitized x-ray image, this new technique can analyze x-ray data to estimate the thickness change of a material. It can be used on existing x-ray images or added to a process plan for future x rays. If the thickness of a reference region is known, the thickness and contours of the entire parts can be estimated based on their geometry. NASA engineering review boards accepted this technique for use on flight hardware procured by the NASA Launch Service Program (LSP). The new non-destructive evaluation technique has been applied to acceptance of testing of flight hardware for use on the Delta II rocket; it has saved thousands of additional testing hours.



Two computer screens display x-ray data that uses calibration tooling to estimate the thickness and contours of entire parts and materials.


The HZETRN code helps design protection for humans and equipment against space radiation on board of the International Space Station.

2007 Software of the Year Nomination

LAR-17327-1: High Charge Z and E TraNsport (HZETRN) 2005

Providing radiation protection and shielding to astronauts in future space exploration is one of the five critical enabling technologies identified in NASA's Strategic Plan for space exploration. The HZETRN code provides the basis for space radiation shield design, spanning length domains from fentometer (subnuclear and nuclear) to submicrometer (atomic and molecular) to meters (subsystems) to decameter (whole systems). Particle energies for particles, such as Z and E particles, vary from thermal (0.025 eV) to very high energy (TeV) during the usual computational process. Modern physics theories and experiments (subnuclear/nuclear/subatomic/atomic/molecular) are involved in developing these computational procedures; these procedures require efficient representations for system design optimization.

This technology focuses on protecting humans and equipment during space flight, space exploration, and commercial aircraft operations. Potential space applications also exist in protecting materials and electronics from the deleterious effects of space radiation. Additional applications outside space exploration are being developed for medical therapy protocols for treatment of cancer and tumors with multiple charged ion beams in U.S. and foreign clinics (Japan and Germany).

A scientist demonstrates the MEMS packaging technique and chip fabrication method to prepare for high-temperature testing.

2008 Invention of the Year Nomination

LEW-17170-1, 17256-1: the MEMS Packaging Technique and Chip Fabrication Method for High-Temperature, Harsh-Environment Silicon Carbide (SiC) Pressure Sensors

This technology has been licensed and already produced $100,000 in royalties, although no commercial product is yet available. These SiC pressure sensors have been used in engine testing up to 600° C. The sensors are mass producible, and other sensors can be made into the SiC chip to provide multifunctional combination sensors. In Shuttle operations, this has the potential to reduce the amount of combined equipment weight by 5 pounds, which would yield a savings of $250,000. There are numerous high temperature markets where the product could be used, but no commercial uses had occurred at the time of submission. The technology was licensed by the manufacturer of the current state-of-the-art devices, which indicates positive market potential of these new devices.

2008 Invention of the Year Nomination

LEW-17301-1: the Multidimensional Contact Angle Measurement Device (MCAMD)

The MCAMD is capable of measuring instantaneous local contact angles and sets a new precedent for catastrophe optics.

Countless projects and industries require a thorough understanding of the wetting and spreading properties of a liquid on a solid surface. This determination requires the instantaneous local contact angles of a liquid drop on a nontransparent substrate. Commercially available contact angle meters only measure the contact angle from one direction (a side view); they cannot investigate the wetting and spreading characteristics of liquids on a surface whose physical or thermal properties are not constant. The MCAMD comprehensively measures the spreading parameters of common liquid drops on solid surfaces, such as instant local contact angles, contact diameters, drop foot heights, identification of profile mode, and capillary flow pattern. This invention also sensitively detects the capillary flow inside the liquid drop. Subsequently, the effects of capillary flow induced by the evaporation on the spreading and contact angles of the liquid on the solid surface can be quantitatively estimated—other commercially available methods cannot do this.

This invention, along with its relevant research results, provides a practical measurement method of instantaneous local contact angles and establishes a precedent of applying catastrophe optics to quantitatively measure relevant parameters. This breaks the status quo that catastrophe optics can only be used to explain natural phenomena without quantitatively determining any physical properties or geometry characteristics. Such phenomena include the formation of rainbows, the emergence of the sparking of the Sun on the sea, the dancing focal lines painted by the Sun on the sand beneath shallow water, and twinkling starlight. All of these examples do not have quantitative measurements of physical or geometry parameters.

LEW-17975-1, 17642-2, 17642-4: Atomic Oxygen Textured Surfaces for Blood Glucose Monitoring Relating to Control of Diabetes

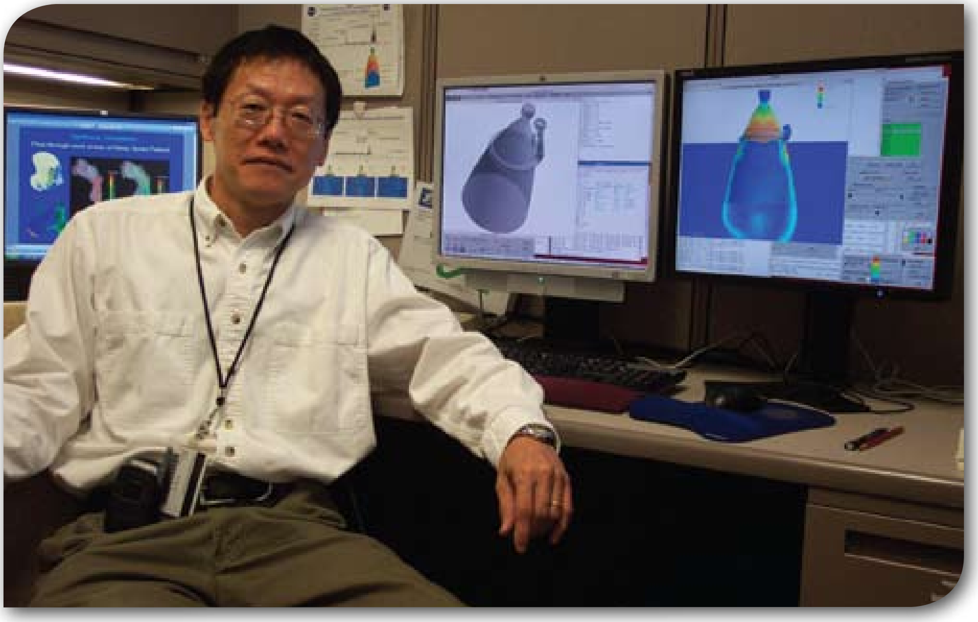
Using atomic oxygen attacking polymers in space, a way to etch the surfaces of an optical fiber to create the correct spacing for blood glucose monitoring was discovered. To keep the surface area and blood sample small, the optical fibers needed to have spacing just less than 5 nm to allow the sensing chemicals to contact the plasma but not the red blood cells. Atomic oxygen does the etching; aluminum vapor deposition controls the spacing of the etched grooves in the optical fiber. QuestStar Medical has had numerous Reimbursable Space Act agreements with GRC to assist in the development of the monitor. The total cost of diabetes in the U.S. in 2002 was $132 billion for direct medical costs and indirect costs (disability, work loss, and premature mortality), and a huge market exists for less painful monitors of blood glucose levels.

A NASA scientist exhibits equipment used to develop atomic oxygen textured surfaces used to monitor blood glucose levels.

2008 Software of the Year Nomination

MFS-32554-1: A Multidimensional, Multiphysics Computational Heat Transfer Analysis Software-Unstructured-Grid Navier-Stokes Internal-External Flow Computational Fluid Dynamics and Heat Transfer Code (UNIC)

UNIC is a multidimensional and multiphysics computational heat transfer code developed for the design and analysis of rocket propulsion components and subcomponents. UNIC performs coupled, simultaneous, steady state, and transient conjugate heat transfer solutions for both fluids and solids, including radiation heat transfer among the solid surfaces and the participating media. In the past, all these computations were done separately and integrated, but UNIC can do them together. In addition, the effects of heat release from turbulent, chemically reacting flows and heat generating solids such as nuclear fuel elements were also included. UNIC has been used to compute the Space Shuttle Main Engine (SSME) thrust performance and wall convective and radiative heat fluxes. The U.S. Air Force (USAF) has used it for an experimental laser lightcraft. It has also been used in several R&D projects at NASA and in universities. Demand for detailed engineering environments increases daily. And for design and decision making purposes, the multiphysics computational

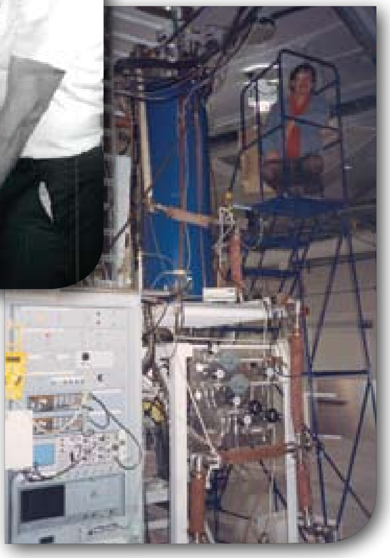


NASA scientists use UNIC to perform heat transfer analysis on rocket engines.

heat transfer technology of UNIC can provide information not achievable with other conventional codes. From a humanitarian viewpoint, this contribution is being used in the University of Alabama in Birmingham for biomedical research, which will create medicines and medical devices to improve human health. This contribution will also be used in Bridgestone APM Company to develop antivibration automotive products that will enhance automobile passenger safety and improve engine fuel efficiency.

NPO-30143, 41273, 17558, 15211, 14254, 13504, 13490, 11437, 10548, 09975: Ruby Microwave Amplification by Stimulated Emissions of Radiation (MASERs) Maximize Performance of Space Missions, Solar System Radar, and Radio Astronomy Receivers

This suite of technologies represents the work of entire careers spent researching low noise amplifiers for deep space communication. Various ruby MASERs for specific applications and associated inventions needed to make them work have resulted in the 11 inventions and 7 patents that are the subject of this award. The Deep Space and Manned Spaceflight Networks all use some of these devices and would have had to be twice the size without them to achieve the same bandwidth. The reduction in data would have made the data obtained much more expensive because the cost of the systems is the same regardless of the data obtained. Observatories around the world use several of these patents. In the NASA systems alone, $80 million has been spent on the development and implementation of these devices.



It took much testing and many years to develop MASERs to improve deep space communication.

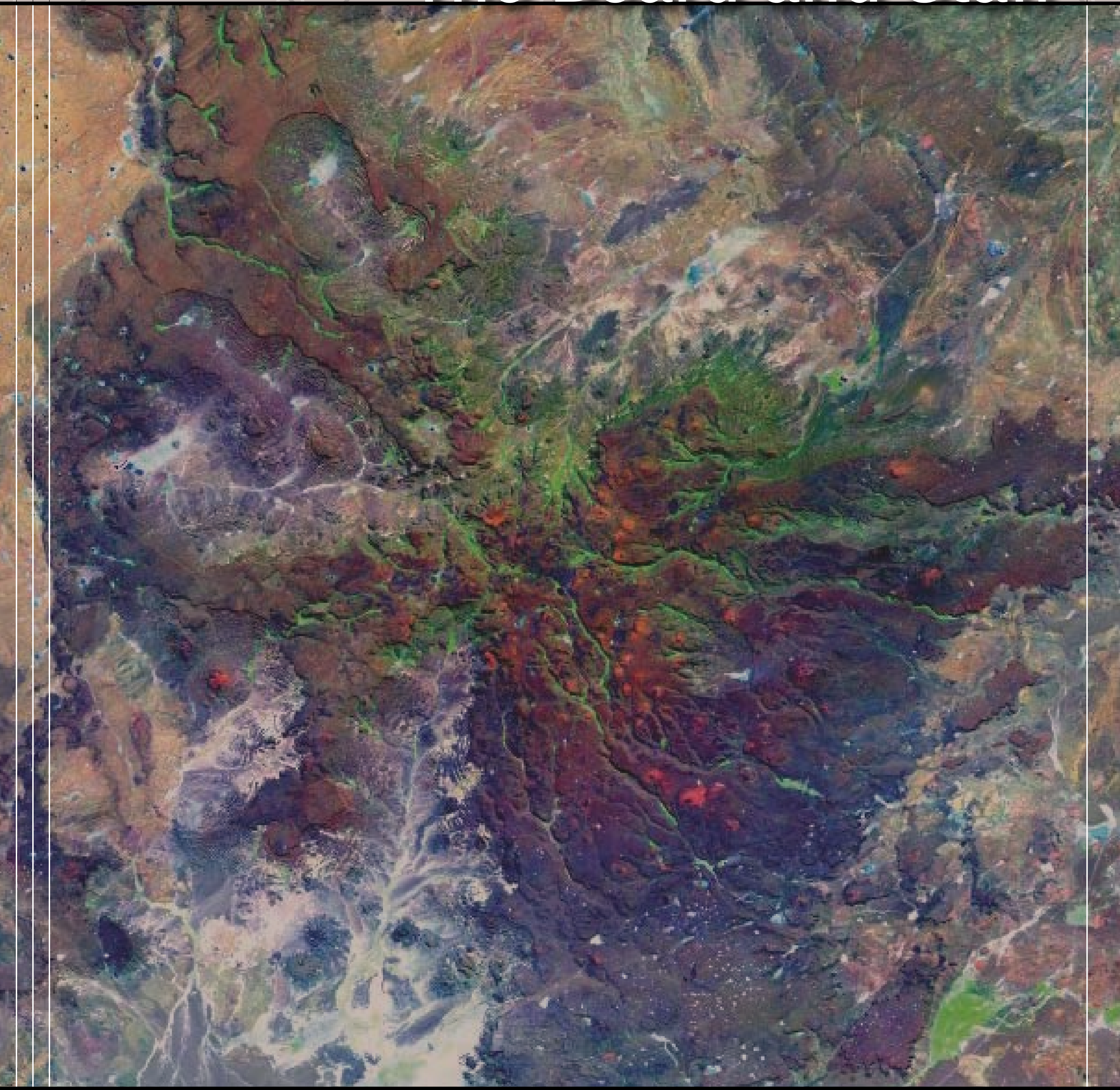
NPO-41261-1: Mars Exploration Rover (MER) Mobility Flight Software

This software has allowed the MERs to rove as far as they have. It allows direct drive or autonomous control over multiple aspects of mobility: motions to drive, measurement of actual motion accounting for slip, geometric terrain interpretation, and even the selection of targets of interest. The inventors submitted 87 pages of journal articles with the application. To summarize the impact of this software, it has more than 20 different types of fault identification that allow the rover to avoid getting stuck or otherwise impeded. With this invention, the inventors estimate that the software has allowed the rovers to travel their combined 18 kilometers in 693 less days, an estimated savings of $37 million in mission operations cost.

The MER mobility flight software enables scientists to drive the rover across multiple types of extreme terrain.

SUPPORTING THE INVENTORS

The Board and Staff



Recognizing the Inventors

The ICB includes the following members:

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A special Software Advisory Panel hears presentations for the Software of the Year Competition and advises the ICB on the ranking of the nominations. This panel consists of software experts from across NASA.

In addition, awards liaison officers and their staff at each Center, patent counsels and attorneys, and technology transfer and software release authority personnel support the ICB. The awards liaison officer contact information is on the next page.

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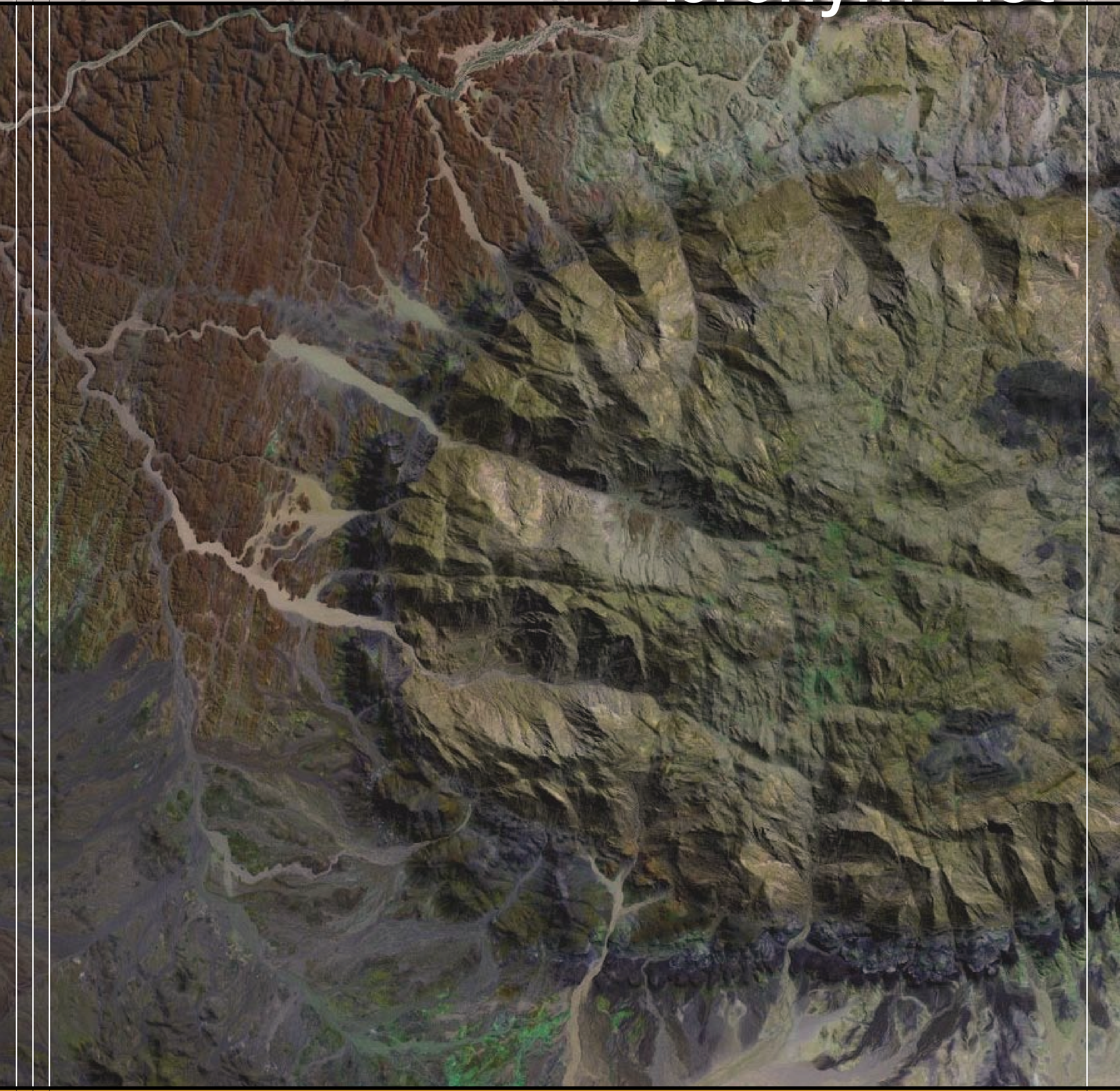
Acronym List



2008 ICB Annual Report Acronym List

3DOF	three-degree of freedom
6DOF	six-degree of freedom
ARC	Ames Research Center
CEV	Crew Exploration Vehicle
CGT	Chimera Grid Tools
DOD	Department of Defense
DOE	Department of Energy
DPLR	Data-Parallel Line Relaxation
GRC	Glenn Research Center
HZETRN	High Charge Z and E TraNsport
ICB	Inventions and Contributions Board
IMS	Inductive Monitoring System
IRC	Interoperable Remote Component
ISHM	Integrated System Health Management
ISP	Information Sharing Protocol
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
KSC	Kennedy Space Center
LaRC	Langley Research Center
LSP	Launch Service Program
MASER	Microwave Amplification by Simulated Emission of Radiation
MCAMD	Multidimensional Contact Angle Measurement Device
MER	Mars Exploration Rover
MGS	Modified Gerchberg-Saxton Phase Retrieval Program
NDT	Non-Destructive Evaluation
OTIS4	Optimal Trajectories by Implicit Simulation, Version 4
RTF	Return to Flight
SiC	Silicon Carbide
SSME	Space Shuttle Main Engine
SWCNTs	single walled carbon nanotubes
TPS	Thermal Protection System
UNIC	Unstructured-Grid Navier-Stokes Internal-External Flow Computational
USAF	U.S. Air Force
UV	ultraviolet
XML	eXtensible Markup Language

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